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# *NINGAUI*, A NEW GENUS OF TINY DASYURIDS (MARSUPIALIA) AND TWO NEW SPECIES, *N. TIMEALEYI* AND *N. RIDEI*, FROM ARID WESTERN AUSTRALIA

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ABSTRACT

*Ningaui* is described as a new genus of small dasyurids with two new species, *N. timealeyi* and *N. ridei*. The similarities of species of the genus *Ningaui* are greatest with species of *Sminthopsis*, but differ from these in construction of the lateral wall of the skull, structure and relative width of the hind foot, more reduced protocone and paracone, and smaller size. Cranial and dental differences also distinguish species of *Ningaui* from those of other similar genera such as *Planigale*, *Antechinomys* and *Antechinus*. *N. timealeyi* from northwestern Western Australia is better-known than *N. ridei* from central Western Australia. Both species occupy relatively arid habitats. Some cranial and dental characteristics are interpreted as arid adaptations. The two species differ from one another in degree of development of the alisphenoid tympanic wing, morphology and size of the post-interdigital hind foot pads, nipple number, and possibly morphology and size of $P_1$ and $P_4$.

Some of the small dasyurids were first recognized as a separate group when Gray (1843) transferred six species *(apicalis, mininus, affinis, leucogaster, flavipes*, and *leucopus)* from *Phascogale* and *Dasyurus* to the genus *Antechinus*, which has been erected by Macleay (1841) for a single species, *A. stuartii*. Waterhouse (1846) agreed with this grouping and included six additional species, but regarded *Antechinus* as a subgenus of *Phascogale*. Gould (1845) recognized *Antechinus* but separated two of the species *(macrourus* and *crassicaudata)*, proposing the name *Podabrus*. As this name was preoccupied by *Podabrus* Westwood, 1840, Thomas (1888) replaced it with *Sminthopsis* in which he included an additional three species *(virginiae, murina*, and *leucopus)*.

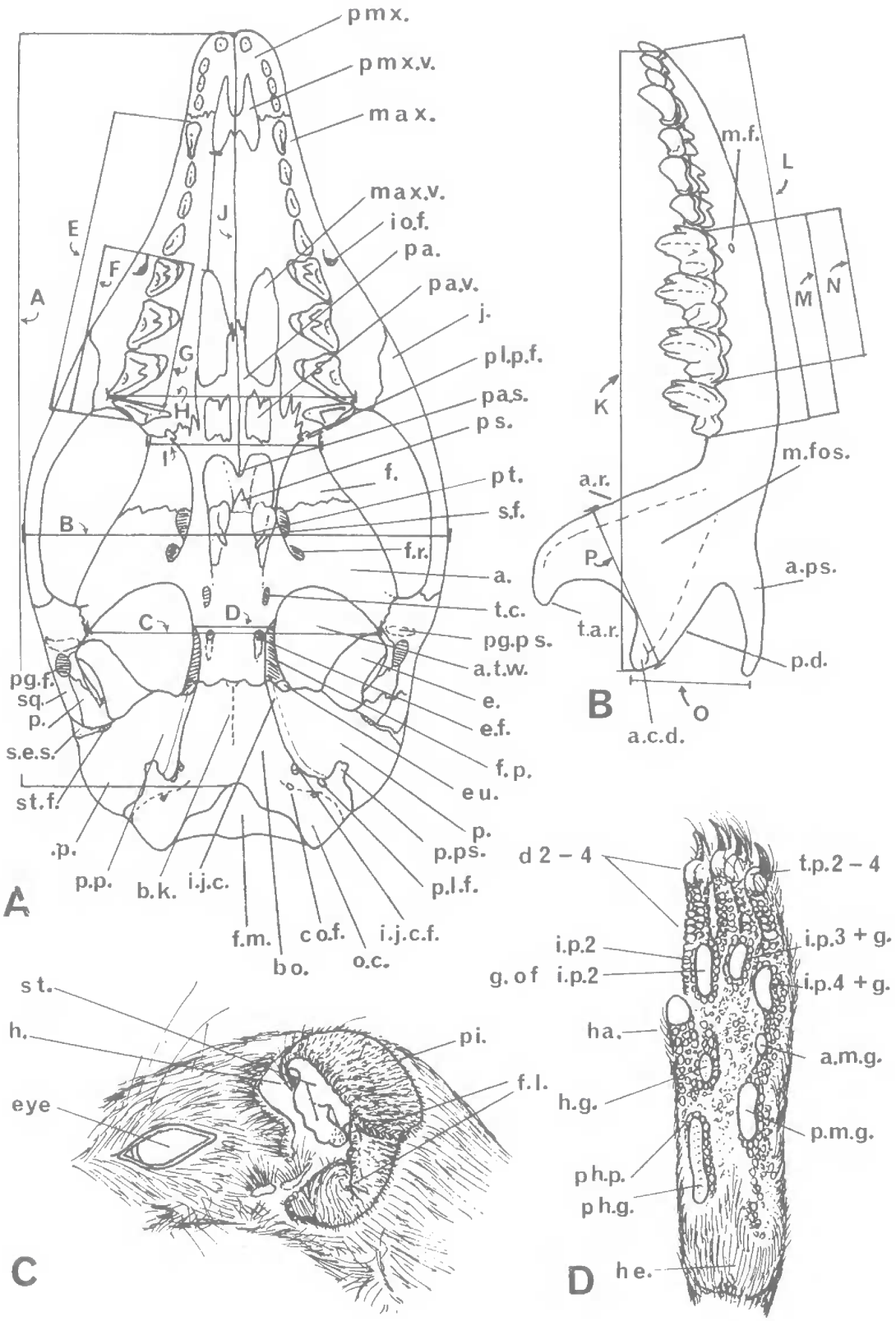
In 1928 a further dasyurid genus, *Planigale*, was proposed by Troughton to receive three of the smallest forms *(ingrami, subtilissima*, and *tenuirostris)*. *Planigale* Troughton has been universally adopted (except Simpson 1945). Tate (1947) recognizes four species, *P. ingrami*, *P. subtilissima*, *P. tenuirostris* and *P. novaeguineae*.

Ride (1970, p. 119) in discussing the Australian species of *Planigale* (i.e. the species not including *P. novaeguineae)* together with *Antechinus maculatus* commented that 'The three ... species ... are commonly put together in one genus, *Planigale*. The fourth species *(maculatus)* is conventionally placed with other *Antechinus*. The relationships of these minute marsupials is largely a matter of conjecture at present. The flat-headed nature of the group is not absolute and I only follow the usual convention in the generic names with considerable reservation. In addition careful examination of the specimens in collections reveals that there are probably more species than the four usually recognized.'

The specimens studied comprise two new species which are sufficiently distinct from all known genera to warrant the erection of a new genus, *Ningaui*. The genus *Planigale*, to which the species had been tentatively assigned by Ride (1970), is re-examined and re-defined.

All catalogue numbers used in this paper unless otherwise indicated are those of the modern mammal collections in the Western Australian Museum. The nomenclature of teeth, hind feet, ears, and basicranial foramina is illustrated in Figs. 1–2. Nomenclature of tooth number follows Archer (1974). Nomenclature of basicranial structures has been determined as part of a broader study of the auditory region of marsupicarnivorans (in preparation).

* Much of this work was carried out at the Western Australian Museum, Perth.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## Family DASYURIDAE

## Genus **Ningaui** nov.

TYPE SPECIES: *Ningaui timealeyi* sp. nov.

### DIAGNOSIS

Dasyurids differing from *Sminthopsis* in being smaller and in having relatively broader pentadactyl hind feet with enlarged apical granules, namely the inner, anterior and posterior metatarsal granules and the hallucal granule; protocone and paracone of $M^{1-3}$ reduced; and no contact between the squamosal and frontal on the outside of the braincase; size as in *Planigale* but differing from these in possessing a relatively narrow hind foot; a curled external edge on the supratragus of the ear; large palatine vacuity; and no posterior cingulum on $M^{1-3}$.

### DESCRIPTION

TAIL: Thin; without brush or crest; approximately equal to or longer than nose–vent (anus) length.

HIND FOOT (Fig. 1D; Plate 28C–D): Apical granules of interdigital and post-interdigital pads* either elongate or round, with or without visible striae or physically expressed striae; pads themselves small; ventral surface of foot without hair except on heel and postero-mesial corner; hallux without claw; and terminal pads of digits smooth.

EAR (Fig. 1C; Plate 27): Supratragus folds back on itself postero-dorsally; helix curls beneath root of supratragus; tragus covered on its anterior edge with short hairs; in pinna, distance between antero-dorsal and antero-ventral points of contact between pinna and head greater than distance from midpoint of line joining those points and postero-external rim of pinna; one to two fold lines present for retraction of pinna; and no conspicuous notch on external rim of pinna.

NOSE: (Terminology as in Pocock 1926.) Median groove pronounced and to top of rhinarium; pronounced groove demarcating whole of external rim of rhinarium; and nostrils centrally placed on each side.

VIBRISSAE: Mysticial vibrissae on each side in five to six ill-defined rows with three to five vibrissae in each row; three to six genal vibrissae; one supra-orbital vibrissa; and two to three carpal vibrissae.

SKULL AND DENTARY: (Figs. 1A–B, 3–4; Plate 29) Nasals parallel or only slightly widened posteriorly, about as in *Sminthopsis*; premaxillary-nasal contact generally longer than nasal-maxillary contact; very slight medial depression in skull between antero-dorsal corners of frontals; no postorbital process on frontal; interorbital constriction narrow and this region distinctly not tubular; lacrimal canal (either one or two on each side) inside or on rim of orbit; infraorbital foramen very large and opens onto surface of maxilla without contact with jugal; lacrimal large but without postero-dorsal spine; venous foramen of frontal conspicuous on dorsal rim of orbit; lack of contact between squamosal and frontal and broad contact between parietal and alisphenoid; premaxillary palatal vacuity does not extend posteriorly beyond alveolus of canine; maxillary vacuity does not extend anteriorly beyond level of $M^1$; palatine vacuity large; incomplete to absent postero-lateral palatal foramen; conspicuous posterior palatal spine; no obvious interdental fenestrae perforating palate; pterygoid with spinous hamular process; alisphenoid tympanic wing large;

*The term post-interdigital is used to include the hallucal and metatarsal granules collectively.

FIG. 1: A, B. Terminology and mensuration of the skull and dentary of *Ningaui* spp., based on WAM M8041 and WAM M6181. *a.*, alisphenoid; *a.t.w.*, alisphenoid tympanic wing (or bulla); *a.c.d.*, articular condyle of dentary; *a.p.s.*, angular process; *a.r.*, anterior face of ascending ramus; *bo.*,basioccipital; *b.k.*, basioccipital keel; *co.f.*, condylar and/or hypoglossal foramen; *e.*, ectotympanic; *e.f.*, entocarotid foramen; *eu.*, eustachian canal opening; *f.m.*, foramen magnum; *f.p.*, foramen pseudovale; *i.o.f.*, infraorbital foramen; *j.*, jugal; *i.j.c.*, internal jugular canal; *i.j.c.f.*, internal jugular canal foramen; *max.*, maxilla; *max.v.*, maxillary vacuity; *m.f.*, mental foramen; *m.fos.*, masseteric fossa; *o.c.*, occipital condyle; *p.*, periotic; *pa.*, palatine; *pa.s.*, palatine spine; *pa.v.*, palatine vacuity; *p.d.*, posterior border of dentary; *pg.f.*, postglenoid foramen; *pg.ps.*, postglenoid process; *p.l.f.*, posterior lacerate foramen; *pl.p.f.*, postero-lateral palatal foramen; *pmx.*, premaxilla; *pmx.v.*, premaxillary vacuity; *p.p.*, petrosal tympanic wing of periotic; *ps.*, presphenoid; *pt.*, pterygoid; *s.e.s.*, squamosal epitympanic sinus; *s.f.*, sphenorbital fissure or foramen; *st.f.*, stylomastoid foramen: *sq.*, squamosal; *t.a.r.*, tip of ascending ramus; *t.c.*, transverse canal. A–P indicate measurements given in Table 2.

C. Terminology of the left ear based on WAM M8041. *f.l.*, fold lines of pinna; *h.*, helix; *pi.*, pinna; *st.*, supratragus.

D. Terminology of the left hind-foot, based on WAM M6181. *a.m.g.*, anterior metatarsal granule; *d2–4*, digits 2 through 4; *g. of i.p.2*, apical granule of 2nd interdigital pad; *ha.*, hallux; *he.*, heel; *h.g.*, hallucal granule; *i.p.2*, 2nd interdigital pad; *i.p.3 + g.*, 3rd interdigital pad and apical granule; *i.p.4 + g.*, 4th interdigital pad and apical granule; *ph.g.*, post-hallucal granule; *ph.p.*, post-hallucal pad; *p.m.g.*, posterior metatarsal granule; *t.p.2–4*, terminal pads 2 through 4.

periotic tympanic wing (from petrosal part) well-developed; mastoid tympanic wing only just developed; ectotympanic develops very small tympanic wing in forms with smallest alisphenoid tympanic wing *(N. timealeyi)*; paroccipital does not develop a tympanic wing although it encloses a small non-auditory sinus; squamosal develops small epitympanic sinus continuous with postglenoid cavity; an abrupt break occurs in the periotic's lateral surface at the level of the horizontal semicircular canal; the mastoid part of the periotic is swollen laterally, the result of a grossly enlarged floccular fossa; foramen pseudovale long and narrow; no true foramen ovale ever develops; entocarotid foramen large, mesial to foramen pseudovale, and leads via short canal to endocranium; no direct ventral observation through entocarotid foramen possible; transverse canal large and pierces basisphenoid mesial to anterior ends of alisphenoid tympanic wings; transverse canal foramen leads directly into endocranial sulcus for entocarotid artery and does not appear to pass transversely through basisphenoid; postglenoid foramen pierces postglenoid cavity immediately posterior to postglenoid process and is separated by thin transparent bone from the much enlarged subsquamosal foramen; entire roof of postglenoid cavity thin, transparent, and functions solely to floor large postglenoid canal; posterior surface of postglenoid process almost horizontal and continuous with roof of postglenoid cavity; rim of postglenoid foramen penetrated anteriorly by postzygomatic foramen which leads into zygomatic arch; small branch of postzygomatic penetrates external surface of zygomatic arch; internal jugular canal very well-developed between basioccipital and periotic with a very steep to vertical basioccipital wall; internal jugular canal actually penetrates basioccipital at anterior end; posterior lacerate foramen passes between paroccipital and periotic dorso-mesially to paroccipital process; complete stylomastoid foramen bordered anteriorly by periotic with small slip of squamosal on ventro-lateral rim; small foramen rotundum floored by variably enlarged shelf of alisphenoid; large sphenorbital fissure; basisphenoid with median ventral keel; ectotympanic wide with marked sulcus and crest associated with pars tensa of tympanic membrane; anterior (dorsal) end of ectotympanic helps enclose mesial wall of postglenoid canal; anterior end of ectotympanic pointed, posterior end blunt; incus as in *Sminthopsis* and other small dasyurids, articulates (not fused) with malleus, with short incudal and long stapedial processes, latter with oval lenticular process at distal end; malleus with pronounced orbicular apophysis, small anterior dorsal spine on head, pronounced capitular crest and lamina, and non-expanded distal tip on manubrium; tubular periotic hypotympanic sinus and almost total lack of development of mastoid epitympanic sinus; incudal fossa of epitympanic recess of periotic large, with well-developed lateral squamosal wall; no sulcus or canal connects facial nerve canal or sulcus with postglenoid canal; periotic horizontal anterolateral projection from epitympanic recess contacts postglenoid foramen and almost excludes squamosal from roof of postglenoid cavity; facial nerve canal large and sulcus well-developed; small foramina sometimes (e.g. WAM M6181) pierce mastoid tympanic wing; fenestra ovalis subrounded rather than oval; endocranial structure of periotic largely unknown because specimens intact but clear that floccular fossa very large and deep, internal auditory meatus divided into widely separate passages for facial and auditory nerves; squamosal reduced in all directions by surrounding bones and squamosal hypotympanic sinus also small; stapes as in other dasyurids, imperforate, collumnar, and with small posterior process for attachment of stapedial muscle and tendon; dentary shallow ventral to teeth; lateral surface of ascending ramus wide; angular process long and slender; mental foramen beneath $M_1$ or $M_2$.

DENTITION: (Fig. 2; Plate 28A, B). $I^1$ tallest upper incisor and set off from $I^2$ by diastema; $I^2$ taller-crowned or subequal to $I^3$ which is taller-crowned than $I^4$; $I^{2-4}$ subequal in crown length; slight buccal cingula developed $I^{1-4}$; $I^4$ lacks posterior cingular cusp or lobe; diastema separates $I^4$ from $C^1$; $C^1$ taller-crowned than any premolar except sometimes $P^4$ which may be subequal in size; $C^1$–$P^4$ not crowded in adult condition, small spaces separating all teeth; in adult condition $P^1$ just shorter-crowned than $P^3$ which is markedly shorter-crowned than $P^4$; buccal cingula complete $C^1$–$P^3$ but incomplete $P^4$ and sometimes incomplete $C^1$; lingual cingula complete $P^{1-3}$ but incomplete $C^1$ and $P^4$; posterior and anterior cingular cusps present $P^{1-4}$ but only posterior cusp present $C^1$; anterior cingular cusps may be small on $C^1$, $P^1$ and $P^4$; $P^4$ blade-like with convex postero-buccal flank; $DP^4$ (WAM M8081) small with two very closely approximated cusps, paracone and metacone, a very small and low protocone, and no stylar cusps; all cusps except protocone linked by longitudinal buccal crest; $M^1$ narrower than $M^2$ which is subequal to $M^3$ which is wider than $M^4$; $M^1$ longer than $M^2$ which is longer than $M^3$ which is longer than $M^4$; paracone increases in size posteriorly but is reduced overall relative to most other dasyurids;

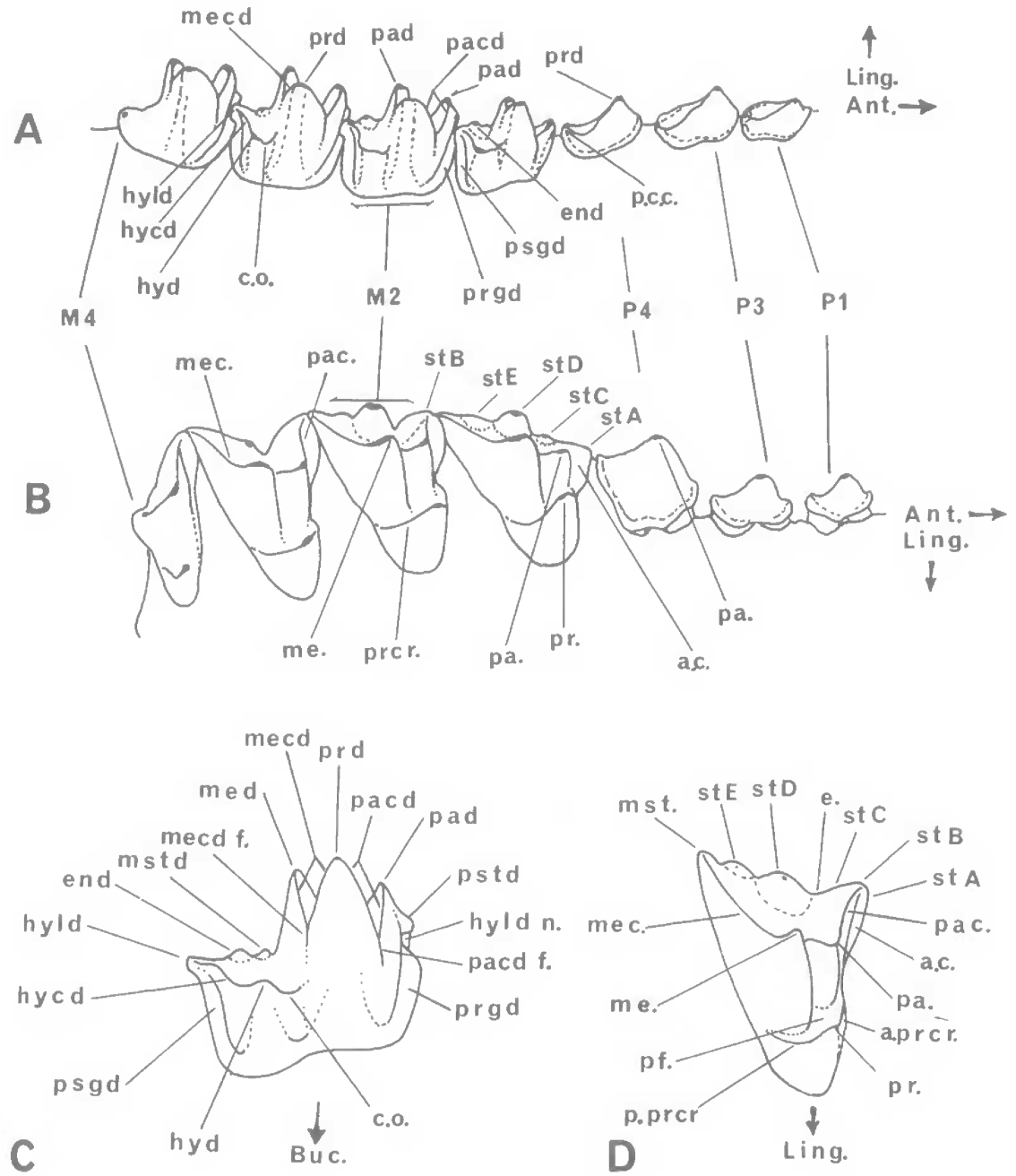


FIG. 2: The terminology of the dentition of *Ningaui* spp. A, lower right $P_1$–$M_4$. B, upper right $P^1$–$M^4$. C, lower right $M_3$. D, upper right $M^3$.

*a.c.*, anterior cingulum; a.prcr., anterior protocrista or preprotocrista; *c.n.*, carnassial notch; c.o., crista obliqua; *e.*, ectoflexus; *end*, entoconid; *hycd*, hyporistid; *hyd*, hypoconid; *hyld*, hypoconulid; *hyld.n.*, hypoconulid notch; *me.*, metacone; *mec.*, metacrista; *mecd*, metacristid; *mecd.f.*, metacristid fissure or cranassial notch; *med*, metaconid; *mst.*, metastylar corner of tooth; *mstd*, metastylid; *pa.*, paracone; *pac.*, paracrista; *pacd.*, -aracristid; *pacd.f.*, paracristid fissure or cranassial notch; *pad*, paraconid; *p.c.c.*, posterior cingular cusp; *pf.*, prefossa; p.prcr., posterior protocrista or postprotocrista; *pr.*, protocone; *prd*, protoconid; *prgd*, precingulid or anterior cingulum; *psgd*, postcingulid or posterior cingulum; *pstd*, parastylid; *stA*, stylar cusp A or position of stA; *stB*, stylar cusp B; *stC*, stylar cusp C or position of stC; *stD*, stylar cusp D; *stE*, stylar cusp E.

paracone and metacone approximated; metacone $M^2$ taller than subequal metacones $M^1$ and $M^3$; metacone $M^4$ absent; protocone small overall and decreases in size posteriorly; very slight protoconule development $M^{1-3}$; no metaconule development; protocone basin opens posteriorly; anterior cingulum complete $M^1$ only antero-buccal cingula well-developed $M^{1-4}$; no posterior cingula; stD present $M^{1-3}$ and decrease in size posteriorly; stB present or position at end of paracrista clear $M^{1-4}$; stB $M^1$ variably developed and may even be absent in some specimens (e.g. WAM M6181) where stB and stA may be indistinguishable; stE variably present $M^{1-3}$ and if present tiny; stA indistinguishable $M^{2-3}$ and sometimes $M^1$; paracrista increases in size posteriorly $M^{1-4}$; metacrista $M^1$ just shorter than that of $M^2$ which is longer than that of $M^3$; ectoflexus increases posteriorly from $M^1$ to $M^3$; $I_1$ taller-crowned and longer than $I_2$ which is taller-crowned and larger than $I_3$; $I_{1-3}$ with slight postero-buccal cingula; poorly-developed posterior cingulum $I_3$; no diastema between $I_3$ and $C_1$; $C_1$ with buccal and lingual cingula; $C_1$ premolariform but just taller-crowned than any premolar; $P_1$ shorter-crowned than $P_3$ which is longer-crowned than $P_4$; $C_1$–$P_3$ wide and contrast with relatively narrow $P_4$; small anterior but well-developed posterior cusps present $P_{1-4}$; well-developed buccal but slightly-developed lingual cingula $P_{1-4}$; premolars contact one another antero-posteriorly but are not crowded; $dP_4$ two-rooted with one main cusp, the protoconid, and possibly a very small posterior cingular cusp; $M_{2-4}$ subequal in length and just longer than $M_1$; talonid $M_1$ wider, $M_2$ subequal to, and $M_{3-4}$ narrower than talonid; protoconid increases in height posteriorly from $M_1$ to $M_3$; protoconid $M_4$ subequal to that of $M_1$; metaconid $M_1$ just shorter than subequal metaconids $M_{2-4}$; paraconid $M_{1-4}$ increases in height posteriorly; hypoconid subequal in height $M_{1-3}$ but just shorter in $M_4$; entoconid miniscule $M_{1-4}$ and variably absent $M_4$; extremely tiny metastylid sometimes present (e.g. WAM M8080) $M_{2-3}$; notch for hypoconulid or its homologue in $P_4$ occurs in anterior cingulum $M_{1-4}$; anterior and posterior cingula well-developed $M_{1-4}$; slight buccal cingula formed only on $M_1$; no lingual cingulum $M_{1-4}$ or posterior cingulum $M_4$; paracristid $M_1$ shorter than and directed more anteriorly than that crest in $M_{2-4}$; paracristid $M_4$ shorter than subequal paracristids $M_{2-3}$; metacristids $M_{1-3}$ increase in length posteriorly; metacristid $M_4$ shorter than that of $M_3$; carnassial notch metacristids well lingual to midpoint of crest; hypocristid longest in $M_2$, subequal in $M_1$ and $M_3$, and shortest or absent in $M_4$; crista obliqua longest in $M_4$ and subequal in $M_{1-3}$; crista obliqua intersects trigonid well buccal to point below metacristid carnassial notch on all molars except $M_4$ where this crest intersects trigonid below metaconid; hypocristid links hypoconid and hypoconulid and does not contact very small entoconid; metacristid and hypocristid $M_{2-4}$ almost transverse to long axis of cheek-tooth row; difference in height of smaller paraconid and larger metaconid decreases posteriorly from $M_1$ to $M_4$, two cusps being subequal in $M_4$; hypoconulid locks into gap (hypoconulid notch) of antero-lingual cingulum of each posterior molar; no cristid links hypoconulid and entoconid; well-developed fissure in paracristid and slight fissure in metacristid $M_{2-4}$; these fissures in $M_1$ very small; tiny parastylid variably developed on $M_{1-4}$.

## Discussion

In diagnosing *Ningaui* comparison has been made with *Sminthopsis* and *Planigale*. There is little risk of confusion with larger forms such as *Antechinus* or *Phascogale*, or with the long-limbed form *Antechinomys* which in a number of characteristics is very similar to some species of *Sminthopsis*. The species of *Antechinomys* share the same characters with species of *Sminthopsis* that enable those species to be distinguished from species of *Ningaui*, i.e. long narrow hind feet (in *Antechinomys* there is additionally a total loss of the hallux) without enlarged post-interdigital granules, and a broad contact on the outside of the skull between the squamosal and frontal bones.

The characters used in the diagnosis of *Ningaui* are not all absolute because some are not expressions of exclusive presence in or absence from *Ningaui*. *Ningaui* must be related to other taxa and it is to be expected that even the diagnostic characters of the genus will reflect these relationships.

The use of the character of the post-interdigital enlarged granules in the diagnosis should not be taken to imply that these granules are invariably small in *Sminthopsis*. Some species of *Sminthopsis* possess slightly or variably enlarged post-interdigital granules, but none have all four post-interdigital granules conspicuously enlarged. For example in the four known specimens of *S. longicaudata*, the three which have feet preserved show an enlarged hallucal and a single enlarged metatarsal granule. However, this species is at once distinguishable from species of *Ningaui* by its possession of the other *Sminthopsis* characters noted above as well as by the extremely long tail (twice the length of the head and body). *Sminthopsis murina* and *S. leucopus* are species which do not

normally possess enlarged metatarsal granules, but one and even two metatarsal granules, as well as a hallucal granule, sometimes occur in abnormal specimens. For example, WAM M1854 *S. murina* has an enlarged hallucal, post-hallucal and slightly enlarged posterior metatarsal granule. Some specimens (e.g. Macleay Museum M1183) of *S. rufigenis* from the Herbert River in Queensland have a slightly enlarged oval posterior metatarsal granule and an enlarged hallucal granule. These species of *Sminthopsis*, however, are otherwise unlike species of *Ningaui*.

In considering the diagnostic dental characters of *Ningaui*, *Sminthopsis ooldea* (= *Sminthopsis murina ooldea* Troughton, 1965) demonstrates some of the dental characters of species of *Ningaui*. For example WAM M8077 has slightly reduced paracones and talonids, although the degree of reduction is not as great as that in species of *Ningaui*. In all other respects *S. ooldea* possesses *Sminthopsis* characters and is easily distinguished from specimens of species of *Ningaui*.

Because of the blurring of these diagnostic characters between *Ningaui* and *Sminthopsis* it is tempting to regard *Ningaui* as a possible derivative or ancestor of that genus. Many of the characters of *Ningaui* occur in *Sminthopsis* as well, where they occur as arid-adaptations of the structurally more generalized form. For example, a detailed study of *Sminthopsis* (in preparation) reveals that there are several species-groups which probably have achieved arid-adaptation independently. Characters involved in such arid-adaptation include small body size, relatively short premolar rows, well-evacuated palates, and high-crowned teeth. Some of these characters can possibly be interpreted as mechanical rather than physiological specializations demanded by thick cuticles of prey species of that environment. In the case of these very small mammals, prey species are likely to be insects with hard cuticles and small vertebrates such as skinks.To masticate such foods it is necessary to have teeth mainly adapted to shear; this may be the reason for the relatively enlarged metacones and trigonids. However, some characters cannot, at present, be understood as mechanical adaptations, such as the lack of contact between the squamosal and frontal. The presence of a squamosal-frontal contact has a peculiar distribution among marsupials. It is present in some *Antechinus macdonnellensis*, *Neophascogale* and *Phascolosorex* spp., some *Phascolarctos cinereus* (Ride 1957), Vombatids, all *Sminthopsis* spp., *Thylacinus* spp., at least some borhyaenids (those whose condition can be determined from figures of Sinclair 1906), hypsiprimnodontine and potoroine macropodids (Pearson 1950), peramelids (*ibid*, and all living genera checked by the present author), zygomaturine, palorchestine and nototheriine diprotodontids (Stirton 1967, Woodburne 1967). It is not present in other dasyurids, macropodine macropodids (Pearson 1950), didelphoids (*ibid* and absence confirmed in this study in *Didelphis*, *Marmosa*, *Monodelphis*, *Metachirus*, and *Philander*), caenolestoids (*ibid* and confirmed in this study in *Caenolestes*), and all other phalangeroids. The absence of this character from all didelphoids and caenolestoids does not suggest that, among marsupials in general, the character is primitive. Moreover, among Australian marsupials it is absent from generalized phalangeroids. If the presence of a squamoso-frontal contact is primitive it would seem that a number of marsupial phyla have achieved it independently from more primitive forms.

I would suggest that the characters of *Sminthopsis* are a derivation from a non-arid-adapted *Ningaui*-like ancestor.

### Origin of Generic Name

The generic name *Ningaui* is here given masculine gender. It is an Aboriginal name given to tiny mythological beings that are hairy, have short feet, and only come out at night to hunt for food all of which is eaten raw (Roberts and Mountford 1969). The allusion to these dasyurids involves their very tiny size, hairy and (compared with the related dasyurid *Sminthopsis* spp.) short feet, and nocturnal habits.

### Species

The genus *Ningaui* contains two species: *N. timealeyi* and *N. ridei*.

**Ningaui timealeyi** sp. nov.
(Figs. 1–3; Plates 28A–C, 29A)

*Planigale tenuirostris:* Ride, 1970, pp. 120, 200 (in part) (*nec* Troughton 1928).

Holotype: Western Australian Museum specimen WAM M6181, young adult female, skull, dentaries, and carcase in spirit, collected by Mr A. Snell, 7 July 1963, 32·2 km southeast of Mt. Robinson, northwestern Western Australia. Specimen 'caught while escaping burning Spinifex'.

Paratypes: WAM M5076, male collected 1957 (E. H. M. Ealey, *in litt.*, 19 September 1972) by Dr E. H. M. Ealey from aerodrome of Abydos Station, W.A. (21°25′S 118°54′E). WAM M8041, male, collected July 1969 by Mr T. Fletcher at Kangan Station, W.A. (21°09′S 118°30′E). WAM M8042, male, collected June 1969 by Mr T. Fletcher from Pilbara Townsite, W.A. (21°15′S 118°18′E).

Referred Specimen: WAM M8729, female, found by Messrs A. Baynes and M. K. Youngson 15 December 1968, in small cave in breakaway about 30 m above sea level, on North West Cape near lighthouse (21°48′S 114°6′E). Found freshly killed with head missing, presumably removed by predator. Specimen referred to *N. timealeyi* on basis of foot structure and general appearance.

### Diagnosis

This species differs from *N. ridei* as follows: Inner and outer posterior metatarsal granules of hind feet elongate; distal end of hallux extends to level of or beyond posterior edge of interdigital pads; hind foot relatively short (HF/NV ratio between 0·17 and 0·20); supratragus of ear relatively long anteroposteriorly; tail exceeds nose-vent length; alisphenoid tympanic wing relatively less well-developed ($M^{1-3}$/outside bullar distance–inside bullar distance value 0·69); $I^2$ length approximately equals $I^4$; nasals may be slightly expanded posteriorly; uninflated ventral portion of periotic larger than periotic tympanic wing; paracrista $M^4$ considerably larger than that of $M^3$.

### Description

Pelage: Ridgeway (1912) colours for holotype (spirit specimen) are as follows: side of face Salmon Colour to Bister; mid-back near Blackish Brown (3) to Chaetura Black; belly near Massicot Yellow to Pale Chalcedony Yellow.

Tail: All specimens have thin tails which exceed nose-vent length (TV/NV ration between 1·13 and 1·36).

Hind Feet: Pads somewhat variable. In holotype, posterior metatarsal granule shorter than post-hallucal granule; in WAM M5076 posterior metatarsal granule present. Hallucal granule also varies in similar manner. WAM M5076, left foot, post-hallucal granule entire; right foot with divided but small separate granule at anterior end. Granules barely striate (when held in incident light some striae reflect light demonstrating very slight surface expression; in others striae are visible, but without surface expression, e.g. as in holotype).

Ear: Supratragus of ear relatively long anteroposteriorly (St/E ratio between 0·25 and 0·29).

Nipple Number: Six (holotype and referred specimen WAM M8729).

Skull and Dentition: Table 1 gives absolute measurements and ratio values. Dorsal, ventral and lateral views of holotype shown in Fig. 3. Characters of teeth shown in Plate 28 where they are accurately illustrated by use of scanning electron microscope. In Fig. 3 damaged areas illustrated unrestored. For example, portion of left jugal, both hamular processes of pterygoid, both alisphenoid tympanic wings and right ectotympanic missing or broken. Also portion of right tympanic wing displaced towards basicranial midline and minor depressed fracture of right alisphenoid. Mild asymmetry of basicranium accurately illustrated. Some basisphenoid foramina of holotype not prepared sufficiently for illustration and as result condition in WAM M8042 shown in Plate 29. In Fig. 3C dentary slightly tilted such that tip of ascending ramus rotated buccally. This shortens apparent distance between tip of angular process and articular condyle. Nasals as shown in Fig. 3A appear to expand posteriorly slightly more than they actually do in holotype. In Figs. 3B and 3C teeth only approximations and their characters should be examined in Plate 28. Figs. 2A and 2B have been made using a camera lucida.

### Habitat

Burbidge (1959) and Ealey (1967) give habitat information for Abydos–Woodstock area which includes locality of paratype WAM M5076. Burbidge (1959) describes flat plain areas as spinifex (*Triodia*) steppe with *Acacia pyrifolia*, *Grevillea pyramidalis* and *Eucalyptus dichromophloia*. Although *Triodia* dominates the grasses, other small plants and bushes occur sporadically. Ealey (1967) describes area as one of erratic summer rainfall (between ten and twelve inches per annum) in which driest months are September to November. He notes that since 1915 number of native grasses in area severely reduced as result of stocking with sheep. Paratype WAM M5076 collected by Ealey amongst *Triodia pungens* and *T. lanigera*. Ealey (*in litt.* 19 September 1972) adds that habitat was shallow sand overlying hard pan with very sparse corkbark trees. Collection area about half mile from water and granite outcrops.

### Reproduction

Holotype has relatively undeveloped nipples. WAM M8041 and WAM M8042 juvenile males collected June and July. Referred specimen WAM M8729 collected in middle December and probably lactating. Has very well-developed pouch with six large nipples.

### Origin of Specific Name

The specific name is in honour of Dr E. H. M. ('Tim') Ealey, of Monash University, who besides collecting the first known specimen of a species of *Ningaui* while an officer of the Wildlife Survey Section of CSIRO, was also responsible for the collection of specimens of rare and little-known species such as *Antechinus rosamondae* from

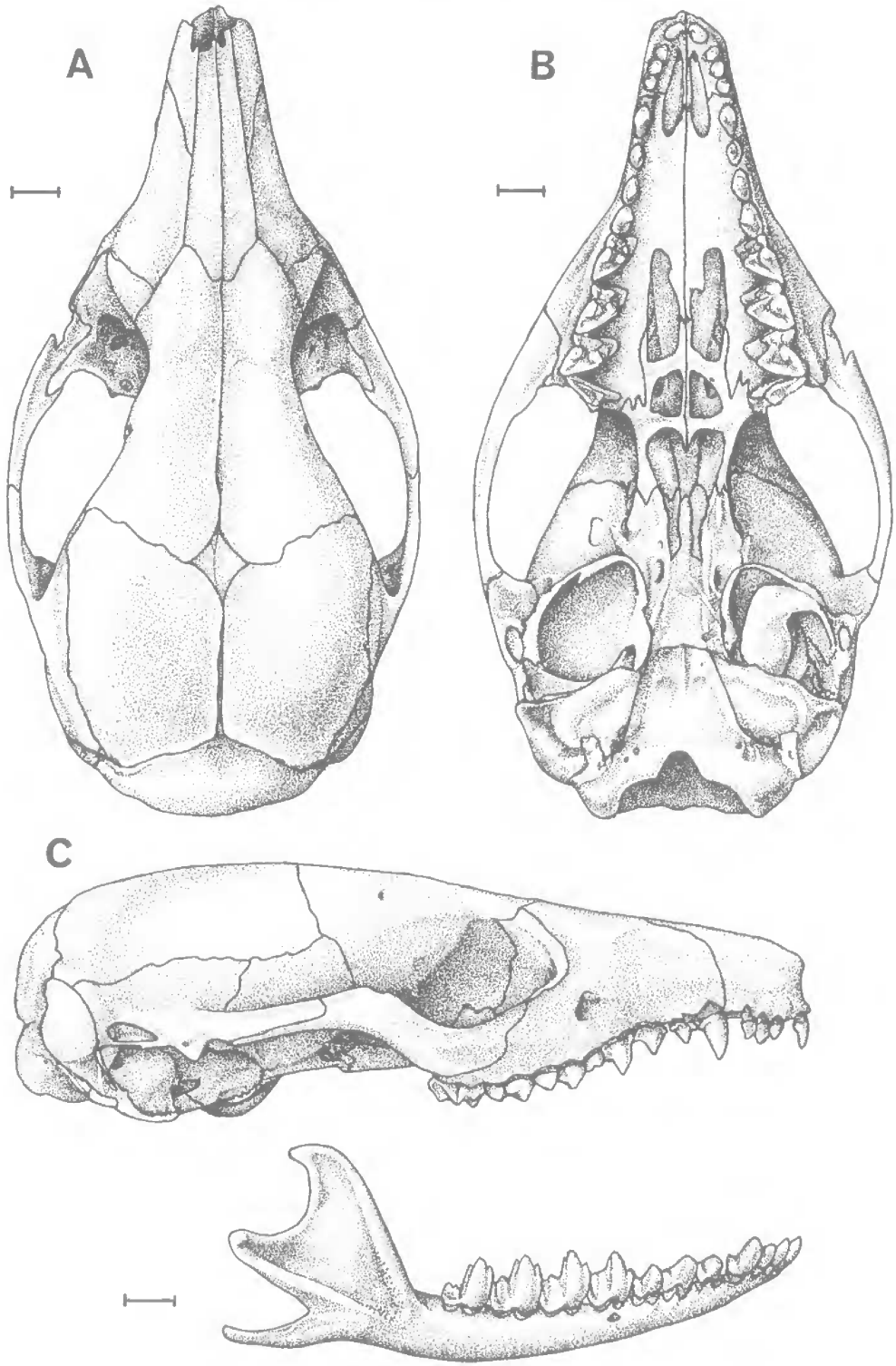


FIG. 3: Holotype *Ningaui timealeyi* sp. nov. (WAM M6181). A, dorsal; B, ventral; C, lateral skull and dentary. Nasals, left jugal and parts of basicranium damaged. Right ectotympanic and most of left and right alisphenoid tympanic wings missing. See text for comments. Line represents one mm.

northwestern Western Australia from 1953 to 1962.

**Ningaui ridei** sp. nov.
(Fig. 4; Plates 27, 28D, 29B)

*Planigale ingrami:* Ride, 1970, pp. 120, 238, pl. 35 (as *Planigale*, close to *P. ingrami*), (in part) (*nec* Thomas 1906).

HOLOTYPE: Western Australian Museum WAM M8080, very young adult female with P4 erupting, skull, dentaries and spirit carcase, caught by Dr and Mrs E. Pianka, February 1967, 38·6 km along White Cliffs Road East-northeast of Laverton, Western Australia (28°30′S 122°47′E).

PARATYPE: WAM M8081, juvenile male with dP4 in place, same collection locality as holotype WAM M8080.

### DIAGNOSIS

*N. ridei* differs from *N. timealeyi* as follows: Post-hallucal and metatarsal granules generally more oval than elongate; distal end of hallux does not reach base of interdigital pads; supratragus outer edge of ear relatively short; tail–vent length just less than nose–vent length; alisphenoid tympanic wing well-developed; periotic tympanic wing relatively large; $I^2$ just larger than $I^4$ and somewhat recurved; nasals do not appear to expand posteriorly; paracrista $M^4$ subequal to paracrista $M^3$.

### DESCRIPTION

PELAGE: Ridgway (1912) colours for holotype (spirit specimen) as follows: side of face near Salmon Colour to Buffy Brown; mid-back near Fiscous-Black to Chaetura Black; belly near Ivory Yellow to Pale Russian Blue.

TAIL: All specimens have thin, relatively short tails (TV/NV ratio 0·96 and 0·97).

HIND FEET: All hallucal and metatarsal granules on hind feet of holotype oval. However, hallucal and posterior metatarsal granules of paratype more elongate than oval; interdigital pad granules either long, partially fused series of small median granules, or shorter somewhat oval apical granule; left foot of holotype shows questionably fused median granules on 2nd and 4th interdigital pads and smaller but isolated apical granule on 3rd interdigital pad; in paratype, situation similar with 3rd interdigital pad having unfused but enlarged oval apical granule; 4th interdigital pad appears to have fused elongated apical granule; 2nd interdigital pad has elongate apical granule but margins indented halfway along to suggest incomplete fusion of median granules; some suggestion of slightly enlarged granule between hallucal and apical granule of 2nd interdigital pad of left foot of paratype; as result, three conspicuous but smaller inner post-interdigital pad granules present; in holotype only two, a hallucal granule and one between it and apical granule of 2nd interdigital pad.

EAR: All specimens have relatively short outer edge of supratargus (St/E ratio 0·20 and 0·22).

NIPPLE NUMBER: The holotype is a young female with seven barely distinguishable nipples. The referred specimen is a juvenile male.

SKULL AND DENTITION: Holotype just barely adult (P4 practically fully erupted); paratype

TABLE 1: EXTERNAL MEASUREMENTS (MM) OF *Ningaui timealeyi* AND *N. ridei* GEN. ET SPP. NOV.

| Species | TV | NV | HF | E | St | TV/NV | HF/NV | St/E |
|---|---|---|---|---|---|---|---|---|
| *N. timealeyi* | | | | | | | | |
| WAM M6181 | 62·0 | 55·0 | 10·0 | 10·6 | 3·0 | 1.13 | 0·18 | 0·28 |
| WAM M8041 | 68·0 | ? | 10·0 | 11·7 | 3·4 | 1·36 | 0·20 | 0·29 |
| WAM M8042 | 79·0 | ? | 10·0 | — | — | 1·32 | 0·17 | — |
| WAM M5076 | 65·0 | 57·0 | 11·0 | 11·5 | 2·9 | 1·14 | 0·19 | 0·25 |
| WAM M8729 | 65·0 | — | 9·0 | — | — | — | — | — |
| $\bar{x}$ | 67·8 | 56·0 | 10·0 | 11·3 | 3·1 | | | |
| s | 6·61 | 1·41 | 0·71 | 0·59 | 0·27 | | | |
| v | 9·75 | 2·52 | 7·10 | 5·22 | 8·71 | | | |
| *N. ridei* | | | | | | | | |
| WAM M8080* | 50·6 | 53·0 | 11·6 | 10·9 | 2·2 | 0·96 | 0·21 | 0·20 |
| WAM M8081* | 48·0 | 49·7 | 11·3 | 11·3 | 2·5 | 0·97 | 0·23 | 0·22 |
| $\bar{x}$ | 49·3 | 51·4 | 11·5 | 11·1 | 2·4 | | | |

*Indicates juvenile or very young adult specimens whose absolute body measurements are probably not indicative of adult body measurements. Abbreviations: TV = tail tip to cloacal vent; NV = nose tip to cloacal vent; HF = hind foot from heel to toe tips not including claws; E = ear from base of notch to tip of pinna; St = supratragus maximum length.

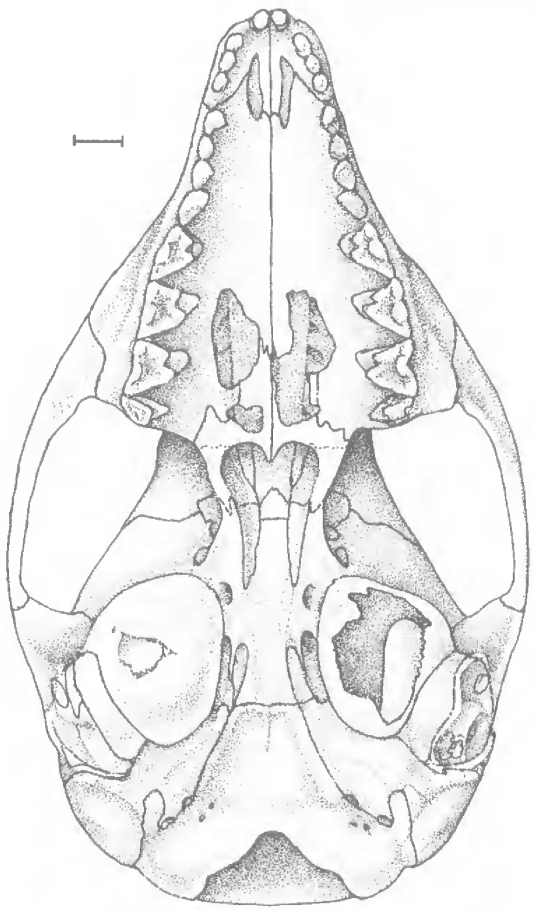

FIG. 4: Holotype *Ningaui ridei* sp. nov. (WAM M8080). Damage described in text. Line represents one mm.

juvenile (dP4 in place). Absolute and relative ratio values given in Table 1. As noted above, the periotic and alisphenoid tympanic wings of *N. ridei* are more enlarged than those of *N. timealeyi* (Plate 29). It is possible that in older individuals of *N. ridei* this difference may become even greater.

## HABITAT

The only two specimens were caught by Dr and Mrs Pianka in February 1967. The holotype was caught in a pit trap dug for lizards. The paratype was collected in spinifex *(Triodia)*. Pianka and Pianka (1970) describe the area within which the holotype and paratype were collected, as open savannah woodland with gently rolling red sand plains, and low lying Triodia meadows. The woodland consists in part of mallee eucalypt and *Eucalyptus gongylocarpa*, some of which grow to 15 m in height, as well as *Acacia* sp. and a ground cover of *Triodia*.

TABLE 2: CRANIAL AND DENTAL MEASUREMENTS (MM) OF *Ningaui timealeyi* AND *N. ridei* GEN. ET SPP. NOV.

| Species | A. basicranial length | B. max. skull width | C. outside bullae distance | D. inside bullae distance | E. $C^1$–$M^4$ | F. $M^1$–$M^4$ | G. $M^1$–$M^3$ | H. $LM^3$–$RM^3$ | I. min. interorbit. | J. interpalatal vacuity | K. dentary condyle to $I_1$ | L. $I_1$–$M_4$ | M. $M_1$–$M_4$ | N. $M_1$–$M_3$ | O. angle–condyle | P. condyle–ramus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *N. timealeyi* | | | | | | | | | | | | | | | | |
| WAM M6181 | 15·7 | 9·1 | 6·3 | — | 6·5 | 3·6 | 3·1 | 5·3 | 3·0 | 2·8 | 12·0 | 7·3 | 4·0 | 2·9 | 3·7 | 3·1 |
| WAM M8041 | — | 9·7 | 6·9 | 2·0 | 7·4 | 3·9 | 3·6 | 5·8 | 3·6 | 3·9 | 14·0 | 8·2 | 4·4 | 3·3 | 3·7 | 3·9 |
| WAM M8042 | 16·2 | 9·2 | 6·8 | 1·8 | 6·6 | 3·8 | 3·5 | 5·5 | 3·5 | 3·3 | — | — | 3·5 | 3·2 | 3·9 | 3·4 |
| WAM M5076 | 17·5 | 10·0 | — | 1·7 | 7·2 | 3·8 | 3·3 | 5·6 | 3·5 | 4·0 | 13·6 | 8·2 | 4·3 | 3·1 | 4·0 | 3·8 |
| $\bar{x}$ | 16·5 | 9·5 | 6·7 | 1·8 | 6·9 | 3·8 | 3·4 | 5·6 | 3·4 | 3·5 | 13·2 | 7·9 | 4·1 | 3·1 | 3·8 | 3·6 |
| s | 0·93 | 0·42 | 0·33 | 0·17 | 0·44 | 0·39 | 0·22 | 0·21 | 0·27 | 0·56 | 1·50 | 0·52 | 0·40 | 0·17 | 0·14 | 0·37 |
| v | 5·64 | 4·42 | 4·93 | 9·4 | 6·4 | 10·26 | 6·47 | 3·75 | 7·94 | 16·0 | 11·36 | 6·58 | 9·76 | 5·48 | 3·68 | 10·28 |
| *N. ridei* | | | | | | | | | | | | | | | | |
| WAM M8080 | 15·4* | 9·8* | 7·2* | 2·0* | 6·2* | 3·8 | 3·4 | 5·7* | 3·3* | 3·1* | 12·1* | 7·4* | 4·2 | 3·1 | — | 3·2* |
| WAM M8081 | — | 9·7* | 7·0* | — | 6·4* | 4·0 | 3·7 | 6·0* | 3·5* | 3·3* | 12·1* | 7·5* | 4·4 | 3·3 | 4·0* | 3·2* |
| $\bar{x}$ | 15·4 | 9·8 | 7·1 | 2·0 | 6·3 | 3·9 | 3·6 | 5·9 | 3·4 | 3·2 | 12·1 | 7·5 | 4·3 | 3·2 | 4·0 | 3·2 |

*Indicates measurements made on juvenile or very young adult specimens which are probably smaller than corresponding measurements made on adult specimens. For example, antero-posterior growth of rostrum and dentary increases A, E, K and L. Similarly, growth of cranium in lateral direction increases B, C, D, H, and I.

### *Ningaui ridei* in Captivity

The holotype was kept in captivity until 13 April 1967, during which time it was photographed. It was also drawn by Mrs E. Fry and forms the basis of plate 35 in Ride (1970). The photographs (Plate 27) reveal that in some respects the living animal does not clearly resemble species of either *Sminthopsis* or *Planigale*. The body is covered with guard hairs which give the animal a bristly appearance, not unlike that of *Antechinus apicalis*, but markedly unlike that of any *Sminthopsis* I have seen. It does resemble the pelage condition of *Planigale gilesi* as suggested by photographs in Aitken (1972). The photographs show that the foot width is broader than that of *Sminthopsis* but distinctly narrower than the feet of *Planigale*. The animal has been photographed while eating a large grasshopper (*Austracris guttulosa, in litt.* J. H. Calaby, 1973). Although the initial seizing of the grasshopper's head is made with the front of the mouth, appendages and projecting body parts are subsequently shifted to the molar region of the dentition where they are sheared off by the large metacristae and paracristids. Dr W. D. L. Ride (pers. comm.) noted that the jumping legs of the grasshopper were quickly severed, perhaps as a way of immobilizing the animal.

### Discussion

The holotype of *N. ridei* is a young adult animal and the paratype a juvenile. All of the specimens representing *N. timealeyi* are adult. Because of this age difference, many of the cranial ratios given in Table 1 are not directly comparable between the two species of the genus.

There are other characters of the canine and premolar region which, when more specimens referable to *N. ridei* are available and the degree of variation is better understood, may prove to be diagnostic. For example, in the only specimen of *N. ridei* in which $P_4$ is visible, it considerably exceeds in length the crown of $P_1$. In *N. timealeyi* on the other hand, the $P_4$ crown is approximately the same length as that of $P_1$.

There also appears to be a difference in the shape of the premolars. In *N. ridei* $P^1$ appears to be broader and more massive in appearance than $P^1$ of *N. timealeyi*. Similarly, $C_1$ and $P_1$ of *N. timealeyi* appear relatively more elongate and narrower than those teeth in *N. ridei*.

The difference in nipple number may, when more specimens of both species are know, prove to be diagnostic. At the moment these characters are not listed in the diagnosis because it is not clear how much variation will be demonstrated by larger samples.

### Origin of Specific Name

The specific name is in honour of Dr W. D. L. Ride, who recognized the complexity and possibly polyphyletic nature of the small marsupials earlier referred to *Planigale*, including the forms described here as species of *Ningaui*.

## RE-DIAGNOSIS OF *PLANIGALE*

The recognition of the difference between species of *Ningaui* and those of *Planigale* enables the genus *Planigale* to be re-diagnosed as follows:

Dasyurids smaller than *Antechinus* and differing from these in having an extremely reduced maxillary vacuity; very small paracone; and small talonid on $M_{1-3}$. Generally smaller in size than *Sminthopsis* and *Antechinomys* and differing from these in possessing a straight external edge on the supratragus of the ear; short broad pentadactyl hind feet; enlarged metatarsal granules; broadened nasals; lack of squamosal-frontal contact on the outside of the skull; posterior cingula on $M^{1-3}$; reduced paracone, protocone, and talonid on M1–3; single-rooted or absent $P_4$; and lack of a palatine vacuity.

Under this concept, *Planigale* contains *P. ingrami*, *P. maculata*, *P. subtilissima*, *P. temuirostris*, *P. novaeguineae* and *P. gilesi* (discussed as part of a revision of *Planigale*, in preparation).

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PLATE 27

Holotype (WAM M8080) *N. ridei* photographed live shortly after capture. A and B show bristly appearance, relatively broad hind foot, fold line of ear, curled supratragus, and use of anterior molar region (presumably large metacones) to cut locust's leg (photographs, W. D. L. Ride).


A


B

PLATE 28

A, B. Scanning electron microscope photographs (composite overlays) of teeth of *N. timealeyi* (WAM M8041). Line is 1 mm in length. A, $RI_1$–$M_4$. B, $RP^1$–$M^4$.

C. D. Left hind foot of *Ningaui* spp. C, Holotype (WAM M6181) *N. timealeyi*. D. Holotype (WAM M8080) *N. ridei*. Ruled lines are 1 mm apart.

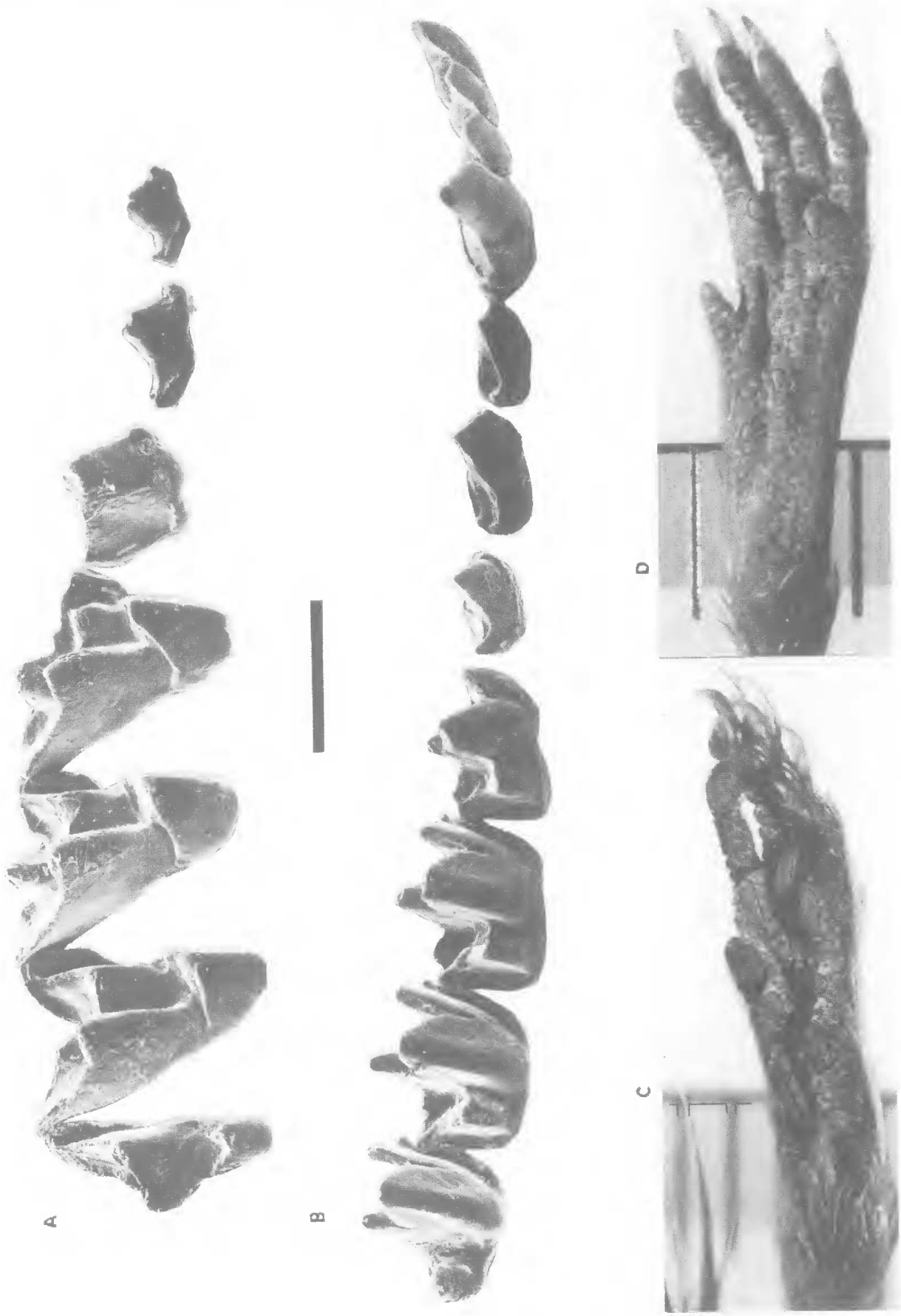
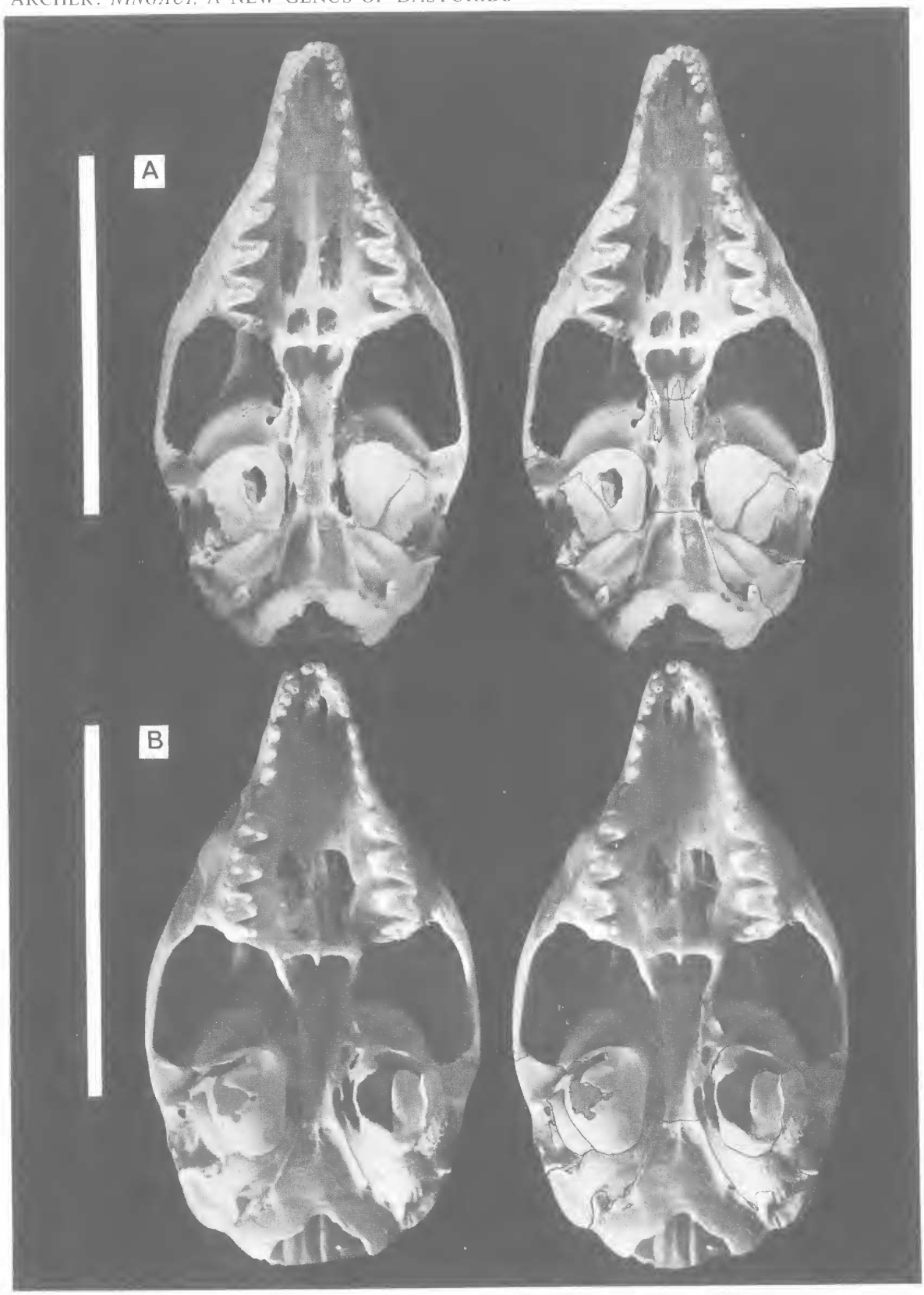

A
B
C
D

PLATE 29

A. B. Ventral view of skulls of *Ningaui* gen. nov. A, *N. timealeyi* sp. nov. (WAM M8042). B, *N. ridei* sp. nov. (WAM M8080). Outlines show differences in basicranial region of two species, and in particular, relative development of alisphenoid tympanic wings. Line represents one cm.


A
B